BAKER BOTTS L.L.P.

30 ROCKEFELLER PLAZA

NEW YORK, NEW YORK 10112

TO ALL WHOM IT MAY CONCERN:

Be it known that I, WERNER AGNE, a citizen of Germany, whose post office address is Himmelgarten 21, 90552 Röthenbach, Germany, have invented an improvement in

DATA TRANSMISSION SYSTEM HAVING DISTRIBUTED CONTROL FUNCTIONALITY

of which the following is a

SPECIFICATION

FIELD OF THE INVENTION

[0001] The invention relates to a data transmission system having distributed control functionality for machine tools and production machines, and robots, hereinafter machine, and further having a networked movement control system which controls complex processes.

BACKGROUND OF THE INVENTION

[0002] A data transmission system which can be used for machine tools, production machines, and robots, is disclosed in the document "Standardisierter Feldbus für die elektrische Antriebstechnik" [Standardized fieldbus for electrical drive

technology], VDI Reports 844, "SERCOS Interface" report, page 69 et seq. The SERCOS interface allows time-controlled bus access to drives. The data messages which are intended for the individual drives are in this case sent in a fixed time frame. An open-loop or closed-loop control system carries out the master function (control functionality) and sends a synchronization signal in time with the cycle time, in response to which the individual drives, i.e., the slaves (secondary functionality), transmit their information to the master.

[0003] A drive concept for a printing machine without a shaft is disclosed in WO 97/11848. There, information which ensures that the angles of the drives are synchronized during printing rotation is transmitted exclusively via a synchronization bus.

[0004] Today, it is becoming increasingly important to provide machine tools, production machines, and robots, (machines) with a network data communications structure, in order to allow production data to be gathered, evaluated and distributed. It is also frequently necessary to match machine units or subunits, and robots, to one another in a production process.

SUMMARY OF THE INVENTION

[0005] The object of the present invention is to provide information for movement control systems, which control complex processes in networked machine tools, production machines, and robots, simultaneously, and even in addition to existing data links. This object is achieved through the discovery that information relating to

movement control can be interchanged by means of real-time, cross-communication between the control functional units. All movement control systems which control complex processes can thus react simultaneously to relevant events in a matched manner.

[0006] In a preferred embodiment of the present invention, real-time cross-communication is carried out using Ethernet links. Using Ethernet makes it is possible to use known bus protocols. Particularly when using fast Ethernet, the very short bus cycles used can result in a wider dynamic range due to the movement control system controlling the complex processes. The wider dynamic range advantageously makes it possible to stabilize process discrepancies more quickly.

[0007] In a further preferred embodiment of the present invention, the control functional units are synchronized by means of Ethernet real-time cross-communication. This enables the stringent requirements for synchronized running to be satisfied, since the master drives can be matched in real time.

[0008] In yet a further preferred embodiment of the present invention, data and synchronization signals from drive regulators are interchanged with an associated control functional unit using Ethernet real-time communication. Matching of all the drive regulators in a drive group using real-time Ethernet advantageously makes use of all the conventions defined in an Ethernet, and allows real-time matching of all the drives in a group. Thus, for example, high-precision and low-error position control actions can be carried out.

[0009] One preferred use of the present invention is in printing machines. In modern printing machines there are a range of individually driven rotating machine elements which are dependent on one another and are matched to one another. A disturbance in a driven machine element in a printing machine can thus also be reported immediately, that is to say in real time, to other machine elements. All movement control systems controlling complex processes can react simultaneously to the disturbance in a matched manner and, for example, can avoid paper jams and torn paper webs. Printing machine downtimes can thus be minimized.

DRAWINGS

[0010] The invention is described in greater detail below and in the context of the drawing, in which:

Figure 1 shows a design of a printing machine.

DETAILED DESCRIPTION OF THE INVENTION

[0011] Figure 1 shows the design of a printing machine, in the form of an overview illustration. Paper webs PB1 to PB3 run from paper rolls P1 to P3 through printing units D1 to D3, and to a folding apparatus F. After passing through the printing unit D1, the paper web PB1 also passes through further processing units; however, they are not shown in the illustration in Figure 1. Thus, in Figure 1, the paper web PB1 ends in a dashed line.

[0012] A printing unit D1 to D3 is represented in the illustration by an approximately H-shaped outer contour. The printing units D1 to D3 each contain ten

cylinders, which are arranged in two groups of five cylinders each. The cylinders refer to all the cylindrical or wheel-like machine elements in a printing unit D1 to D3, and in a folding apparatus F. The paper webs PB1 to PB3 run via these groups, which are referred to as printing points in the printing units D1 to D3.

[0013] A printing point essentially comprises a rubber cylinder, a plate cylinder and an inking and moistening mechanism. Each printing point can print ink on one side. All the printing points which act on a folding apparatus F, that is to say whose printed paper webs PB1 to PB3 are passed to a folding apparatus F, are included in a rotation process. In this case, the printing units D1 to D3 are normally accommodated in printing towers. Each individually driven cylinder has an associated drive with a drive regulator A1 to A35. The drive regulators A1 to A35 of a printing unit D1 to D3 and of the folding apparatus F have a drive regulator A1 to A35 with a control functionality LF1 to LF4, for each group. A group comprises drive regulators A1 to A35 which are networked intrinsically in the form of a ring. However, an important feature is that a drive regulator A1 to A35, with control functionality LF1 to LF4, is available for a group. Any other data networking which can be carried out within a group is thus also possible. This also includes, for example, serial or star linking. The drive regulators A1 to A35 are represented by an open, virtually square, rectangle. The drive regulators A1 to A35, which have control functionality LF1 to LF4, are identified by a boundary represented by a thicker line.

[0014] There is a data link from the control functional units LF1 to LF4 to a respectively associated control computer L1 to L4. The control computers L1 to L4 are connected to a control computer communication system LK1 to LK3. This is illustrated in the drawing by a dashed line. Other embodiments of the data networking are also possible.

[0015] A control computer L1 to L4 carries out higher-level process organization and, in the process, normally defines data or parameters that are not time-critical. Thus, for example, the control computers L1 to L4 can be used to define the printing units D1 to D3 via which a paper web PB1 to PB3 will run, and which drives are intended to run synchronously to one another.

[0016] In the event of a fault, an operator of a printing machine thus has flexibility to decide which of the printing units D1 to D3 will be used. However, this also requires the capability to pass information relating to movement control flexibly to individual printing units D1 to D3. According to the present invention, this is achieved by cross-communication Q1 to Q3. The cross-communication Q1 to Q3 is a data link with real-time capability and thus ensures that essential information is available at all movement control points simultaneously. This includes, for example, synchronization and error signals, and signals which necessitate immediate action.

[0017] The drives A1 to A25 are associated with the folding apparatus F in the illustration shown in Figure 1. The drive A21 has the control functionality LF3 for the drive group associated with the folding apparatus F.

[0018] In what follows, it is assumed that a specific fault in the folding apparatus F can be rectified by reducing the speed of the paper work. Once this fault has been detected, the drive A21 with the control functionality LF3 of the holding apparatus F transmits a speed reduction signal to other control functional units LF1 to LF4. The control functional units LF1 to LF4 know, via the control computers L1 to L4, which drive regulators A1 to A35 are controlling the paper webs PB1 to PB3 of the folding apparatus F. The respective control functional units LF1 to LF4 signal the above-mentioned speed reduction to the necessary drive regulators A1 to A35.

[0019] The cross-communication Q1 to Q3 in real-time means that all the control functional units LF1 to LF4 have this information at the same time. Once a fault has been identified and a counter measure has been initiated, this leads to an immediate reaction at the same time in the drive groups. This advantageously allows an improved printed product quality to be achieved.

[0020] Since all the control functional units LF1 to LF4 are connected by means of real-time cross-communication Q1 to Q3, this ensures that all the information relating to movement control is available all the time throughout the system. Even if the system operator has to reconfigure the system, in terms of the profile of the paper webs PB1 to PB3, as a result of a fault, there is nevertheless no need for him to carry out any rewiring for information distribution. In particular, complex, freely configurable production lines which use machine tools, production machines, and robots in the end profit from the real-time capability of the cross-communication Q1 to Q3. It is even conceivable for such

flexibility to be made possible for the first time by the use of cross-communication Q1 to Q3 with a real-time capability.